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## THE DETERMINATION OF A CARBURETOR SETTING FOR THE LIBERTY ENGINE FOR DIRIGIBLE USE

(POWER PLANT SECTION REPORT)

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# THE DETERMINATION OF A CARBURETOR SETTING FOR THE LIBERTY ENGINE FOR DIRIGIBLE USE.

## OBJECT OF TEST.

The purpose of this test was to develop a carburetor setting for the Liberty 12-cylinder engine adapting it for dirigible service.

## SUMMARY AND CONCLUSIONS.

The recommended carburetor setting to be used in conjunction with the Zenith U. S. 52 carburetors is 24-millimeter chokes, 1.15-millimeter main jets, and 1.20-millimeter compensator jets. This setting is to be used to obtain approximately 280 horsepower at 1,400 revolutions per minute. At this output the Liberty engine will weigh 3 pounds per horsepower.

## INTRODUCTION.

The main performance characteristics required of a dirigible engine are durability (even if obtained at the sacrifice of low weight per horsepower), low-fuel consumption over a wide range of speed, ability to run smoothly throughout the speed range, and a low-idling speed. By choking down the output to about 280 horsepower and reducing the normal full throttle speed from 1,700 revolutions per minute to 1,400 revolutions per minute (at this output the Liberty engine will weigh 3 pounds per horsepower), it is believed that the standard Liberty "12" engine will fulfill these requirements in a satisfactory manner.

A further reason for reducing the output to 280 horsepower is that this is the power output of the Renault engines, which are now in use on several Army dirigibles and which will be replaced by Liberty engines.

## METHOD OF TEST AND DISCUSSION OF RESULTS.

A Liberty "12" cylinder engine, with 6 $\frac{1}{2}$ :1 compression ratio, was mounted on the dynamometer. The engine was equipped with standard Liberty Zenith Model U. S. 52 carburetors with standard Liberty settings of 36-millimeter chokes, 1.65-millimeter main jets, and 1.70-millimeter compensator jets. Domestic aviation gasoline (War Department Specification No. 2-40) was used, unblended with any antidentalating compound. It was proposed to eliminate detonation by throttling and in that manner take advantage of the higher compression to obtain low fuel consumption. With the output throttled, as proposed, to 280 horsepower at 1,400 revolutions per minute, detonation was encountered, and since it was not desired to use antidentalating compounds further trials with the high compression were abandoned.

A standard Liberty 12-cylinder engine, with standard compression ratio and standard Liberty carburetor setting, was next mounted on the dynamometer. A plate, with a hole 1.250 inches in diameter, was placed above the carburetor in each intake manifold, which on several check runs, it was determined, limited the power output to 280 horsepower at 1,400 revolutions per minute. With this arrangement a corrected output of 291 horsepower and a fuel consumption of 0.470 pound per horsepower per hour were obtained at 1,400 revolutions per minute. Data for these runs are not included in this report, as this method of throttling, it was believed, would probably cause loading up of fuel at the plate, with consequent irregular operation of the engine.

A series of check runs was then made on the same engine to obtain the carburetor setting with a reduced carburetor choke which would give approximately 280 brake horsepower at 1,400 revolutions per minute. Two full-power runs, a friction horsepower run, and two propeller load runs were made with 24-millimeter chokes, 1.10-millimeter main jets, and 1.30-millimeter compensator jets, which was determined to be the proper setting. Data for these runs, a power curve and a drawing of the Venturi choke, are given on pages 4 to 8. The full-power curve shows an output of 294 brake horsepower and a fuel consumption of 0.460 pound per horsepower per hour at 1,400 revolutions per minute. It will be noted that the fuel economy on propeller load operation is good, even at the lower speeds.

On completion of the above runs it was decided to make additional runs with a larger main jet, as it was feared that in flight service the 1.10-millimeter jet might give a mixture so lean as to interfere with acceleration and cold-weather operation. The main jet was therefore increased to 1.15 millimeters. To give a more balanced setting, the compensator was reduced to 1.20 millimeters. The choke size was not changed.

It was found expedient further to conduct these tests on a 6-cylinder Liberty engine instead of a 12-cylinder. By using an adapter it was possible to feed all six cylinders from one Zenith U. S. 52 carburetor, each barrel of which fed a bank of three cylinders. In this manner all the conditions obtained on a 12-cylinder engine were exactly reproduced, except that the power output was one-half of that of a 12-cylinder engine. Full-power runs at normal speed were made on the dynamometer both with the original setting and with the enriched setting. As shown on page 6, the power output with the two settings is approximately the same at 1,400 revolutions per minute with a specific fuel consumption for the richer

setting of 0.520 pound per brake horsepower per hour at full rich operation. Tests for the performance of this setting as regards acceleration, idling, etc., were made on the torque stand. The acceleration and operation at all speeds on the torque stand was entirely satisfactory. The lowest idling speed obtained was 210 revolutions per minute.

It will be noted that the power output obtained with this revised setting (allowing for the difference in the number of cylinders) is practically the same as was first obtained on the dynamometer runs on the 12-cylinder engine with the "24-110-130" setting though the fuel consumption in the full rich position is slightly higher. A leaner mixture can, of course, be obtained by use of the mixture control. For these reasons the power curves

attached herewith for the "24-110-130" setting also fairly represent the performance that can be obtained with the "24-115-120" setting, provided the altitude control is properly used.

#### RECOMMENDATIONS.

It is recommended that for dirigible service the standard Liberty 12-cylinder engine be equipped with the following carburetor setting: 24-millimeter chokes, 1.15-millimeter main jets, and 1.20-millimeter compensator jets. This setting gives slightly over 280 brake horsepower at 1,400 revolutions per minute with good fuel economy and smooth operation at all speeds. To obtain maximum fuel economy, the carburetor mixture control must be properly used.

#### STANDARD LIBERTY "12" WITH FIRST (LEAN) SETTING.

##### *Full-power runs.*

##### FIRST RUN.

R. p. m.	Actual—		Corrected—		Water.		Oil.		Carb. air temp. °F.	Man vac., in. hg.	Sec. for 3 lbs.	Fuel cons. Lb. per hp.-hr.				
	Brake load, lbs.	B. hp.	B. m. e. p., lbs. per sq. in.	Temp. °F.	In.	Out.	Temp. °F.	Pres- sure, lbs. per sq. in.								
					In.	Out.										
1,000	704.0	234.6	240.4	115.4	137	173	91	104	43	85	1.9	103.0	0.447			
1,100	692.0	233.7	260.0	113.4	145	174	92	104	44	85	2.2	93.8	.454			
1,190	672.0	266.5	273.0	110.1	140	170	93	106	45	85	2.6	86.8	.467			
1,290	643.5	276.8	283.7	105.5	141	169	94	109	45	85	3.1	84.8	.460			
1,390	617.5	286.2	283.2	101.2	141	170	94	115	46	85	3.5	81.6	.463			
1,490	590.0	283.0	300.3	96.8	142	168	95	119	47	85	3.8	80.8	.456			
1,600	567.0	302.5	310.0	93.0	144	170	96	124	47	85	4.2	78.4	.456			

##### SECOND RUN.

1,000	700.0	233.2	239.0	114.7	142	175	96	107	44	86	1.9	100.0	0.463
1,090	691.0	251.1	257.4	113.3	138	171	96	107	44	86	2.2	93.2	.462
1,190	671.5	266.4	273.0	110.1	137	169	97	108	45	86	2.6	88.2	.460
1,290	643.0	276.5	283.4	105.4	143	170	97	109	45	86	3.1	83.8	.466
1,400	617.5	288.2	295.3	101.2	145	175	97	113	46	86	3.5	82.6	.454
1,490	588.0	292.0	299.3	96.4	141	168	97	118	46	86	3.8	79.6	.465
1,590	568.5	301.3	308.8	93.3	141	167	98	122	47	86	4.1	78.6	.456

Data for both runs:

Length of brake arm, 21 inches.

Kind of oil used, Spec. No. 2-23.

Kind of fuel used, domestic aviation gasoline.

Specification, No. 2-40.

Specific gravity of gasoline, 0.697 at 63.4° F.

Sparc plugs used, a. c.

Barometer, 29.19 in. hg.

Position of altitude control, 6.0 (6.75 = full rich position).

Zenith U. S. 52 carburetor setting:

Choke, 24 mm.

Main jet, 1.10 mm.

Compensator jet, 1.30 mm.

Jet flow under head of 50 centimeters—

Main jet, 15.98 imperial pints per hour.

Compensator jet, 23.46 imperial pints per hour.

## Propeller load runs.

## FIRST RUN.

R. p. m.	Actual—		Cor- rected hp.	Water.		Oil.		Carb. vac., in. hg.	Man. vac., in. hg.	Fuel cons.				
	Brake load, lbs.	B. hp.		Temp. °F.		Temp. °F.				Sec. for 3 lbs.	Lb. per hp.-hr.			
				In.	Out.	In.	Out.							
1,410	613.0	288.0	295.2	141	168	97	110	45	86	3.5	81.2			
1,280	534.0	227.8	233.5	143	167	98	112	45	86	3.8	107.8			
1,190	456.0	180.8	185.3	145	168	98	111	44	87	4.5	133.6			
1,090	380.0	138.1	141.5	148	171	99	109	44	87	6.4	162.0			
1,010	314.0	105.7	108.3	148	168	99	107	44	87	8.4	199.0			
900	254.0	76.2	78.1	147	169	99	105	43	87	11.1	258.3			
810	202.0	54.5	55.9	150	169	99	102	40	88	13.2	325.2			
											161.0			

## SECOND RUN.

1,390	609.5	282.5	289.5	143	168	97	115	44	87	3.5	80.0	0.478
1,290	536.0	230.5	236.3	145	168	99	115	44	87	3.7	104.8	.447
1,180	454.0	178.6	183.0	145	167	99	114	43	87	4.3	129.6	.467
1,100	381.0	139.7	143.2	148	168	99	111	43	87	5.8	156.6	.494
1,010	315.0	106.1	108.7	148	170	100	108	43	87	8.0	194.4	.522
890	254.0	75.3	77.2	149	172	100	107	42	87	10.7	256.0	.581
790	200.0	52.7	54.0	148	169	100	110	34	87	13.1	323.4	.634

## Data for both runs:

Length of brake arm, 21 inches.

Kind of oil used, Spec. No. 2-23.

Kind of fuel used, domestic aviation gasoline.

Specification, No. 2-40.

Specific gravity of gasoline, 0.697 at 63.4° F.

Spark plugs used, a. c.

Barometer, 29.19 in. hg.

Position of altitude control, 6.0 (6.75 = full rich position).

Zenith U. S. 52 carburetor setting:

Choke, 24 mm.

Main jet, 1.10 mm.

Compensator jet, 1.30 mm.

Jet flow under head of 50 centimeters—

Main jet, 15.98 imperial pints per hour.

- Compensator jet, 23.46 imperial pints per hour.

## LIBERTY "12" ENGINE.

## FRICTION HORSEPOWER RUN.

R. p. m.	Fric- tion load, lbs.	Fric- tion horse- power.	B. hp. (from curve).	Mech. eff. per cent.	Water.		Oil.		Pres- sure, lbs. per sq. in.	
					Temp. °F.		Temp. °F.			
					In.	Out.	In.	Out.		
800	67	17.9	.....	.....	165	167	100	118	36	
900	71	21.3	.....	.....	168	170	100	118	40	
1,000	74	24.7	239	90.6	167	170	100	120	42	
1,100	79	29.0	259	90.0	167	170	100	124	43	
1,200	84	33.6	274	89.0	167	170	100	128	43	
1,300	90	39.0	285	88.0	167	170	100	131	44	
1,400	95	44.4	294	87.0	167	170	100	133	45	
1,500	101	50.5	302	85.6	167	170	101	137	46	
1,600	109	58.2	308	84.2	167	170	101	138	46	

Room temperature, 85° F.

Zenith U. S. 52 carburetor setting.—Choke, 24 mm.; main jet, 1.1 mm.; comp. jet, 1.3 mm.

## LIBERTY "6" ENGINE.

Check full-power runs at 1,400 R. p. m.

## FIRST RUN (first setting determined).

R. p. m.	Actual—		Corrected—		Water.		Oil.		Carb. air temp. °F.	Rear man. vac., in. hg.	Front man. vac., in. hg.	Fuel cons., lb. per hp.-hr.				
	Brake load, lbs.	B. hp.	Hp.	B.m.e.p., lbs. per sq. in.	Temp. °F.	Temp. °F.	Pres- sure, lbs. per sq. in.									
					In.	Out.										
1,420	295.0	139.6	143.2	96.9	150	166	99	104	26	86	3.5	3.9	0.499			
1,420	295.5	139.8	143.4	97.1	155	171	101	107	26	86	3.5	3.9	0.492			

Zenith U. S. 52 carburetor setting.

Choke, 24 mm.

Main jet, 1.10 mm.

Compensator jet, 1.30 mm.

Jet flow under head of 50 centimeters:

Main jet, 15.98 imperial pints per hour.

Compensator jet, 23.46 imperial pints per hour.

## SECOND RUN (enriched setting).

1,420	299.0	141.5	145.2	98.2	154	167	104	105	26	86	3.5	4.0	0.511
1,410	300.0	141.0	144.6	98.5	155	170	106	108	26	86	3.5	4.0	0.523
1,400	300.5	140.2	143.8	98.8	152	168	106	110	26	86	3.5	4.0	0.526

Zenith U. S. 52 carburetor setting:

Choke, 24 mm.

Main jet, 1.15 mm.

Compensator jet, 1.20 mm.

Jet flow under head of 50 centimeters:

Main jet, 17.34 imperial pints per hour.

Compensator jet, 20.16 imperial pints per hour.

Data for both runs:

Length of brake arm, 21 inches.

Kind of oil used, Spec. No. 2-23.

Specific gravity of gasoline, 0.697 at 63.4° F.

Spark plugs used, a. c.

Barometer, 29.17 in. hg.

Altitude control, full rich.

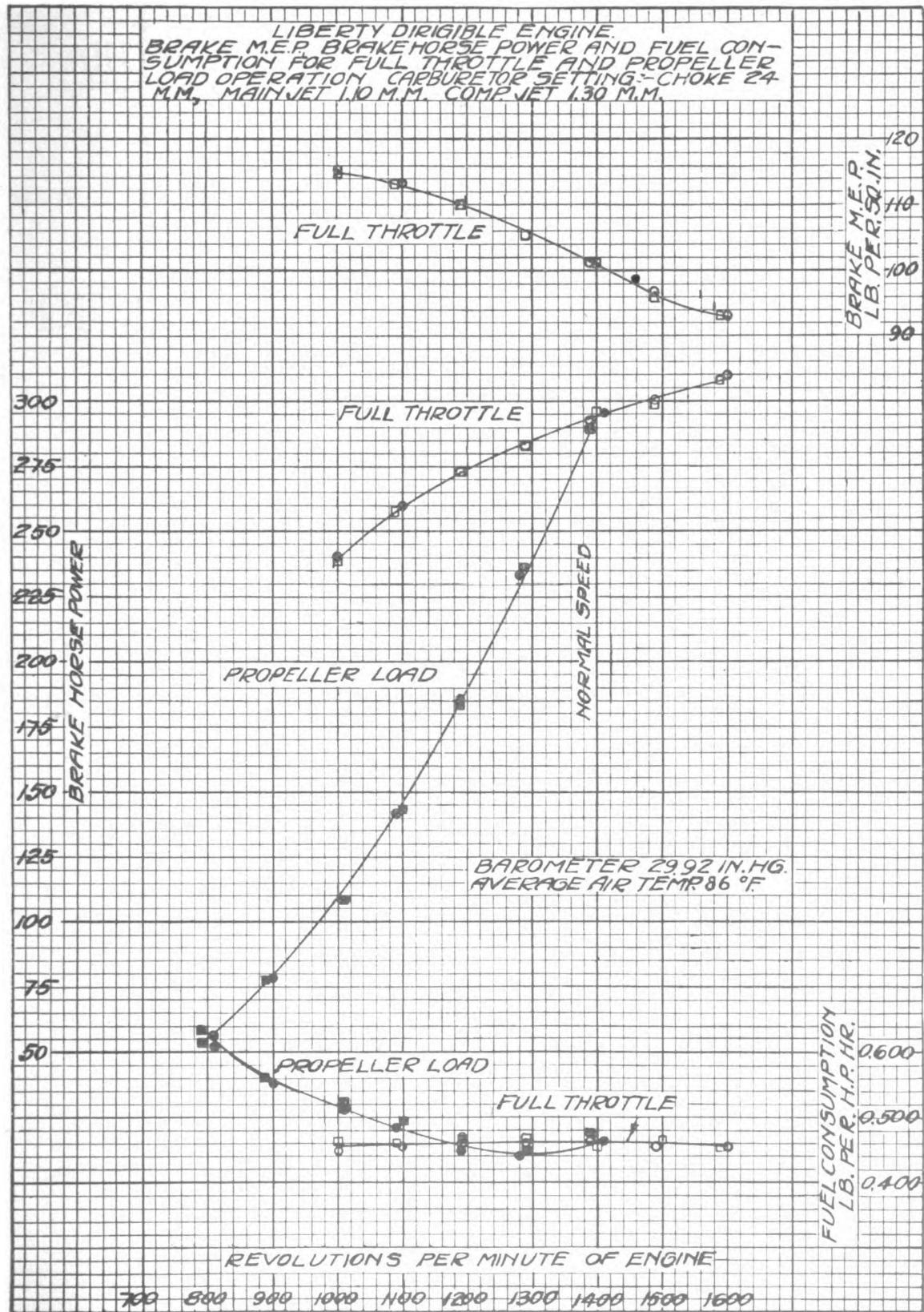
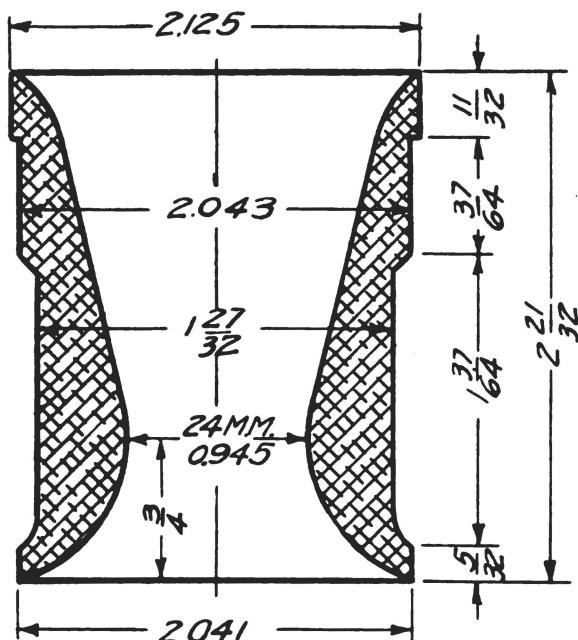


FIG. 1.



NOTE.—All dimensions except as noted are in inches.  
FIG. 2.—Liberty dirigible engine. 24 mm. choke for Zenith U. S.  
52 carburetor.